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AUTHOR Upitis, Rena
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ABSTRACT

In this chapter, a college teacher describes the use of personal projects in a class on mathematics teaching for preservice teacher-education students. The personal project required students to learn something new or to do something they had never done before, and to document their learning through a journal or other reflective record. In addition, students were asked to discover the role of mathematics in their project, although math was not to be considered in choosing a project. The assignment carried no threat of evaluation; all students were given an "A." Students chose a wide variety of projects, although many involved artistic expression or handicrafts. Journal excerpts present student reactions at various stages of the project. Initial reactions ranged from elation at being allowed the choice of what to learn, to fear of the open-ended nature of the assignment, to feelings that the assignment would not be valuable in terms of mathematics education. Common occurrences during the early phases of the project included students changing their minds about their projects and the experience of gathering materials. During mid-phases, students often experienced frustration, impatience, and anxiety. By project completion, students had discovered that mathematics was involved in their project, had begun to "see math everywhere," and had gained increased confidence in their own math abilities. For preservice teachers, thinking about their own learning invariably led to new ways of thinking about teaching and to real commitment to lifelong learning. Contains 36 references. (SV)

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RC 020691

Chapter 14

NO STRINGS ATTACHED: PERSONALIZING MATHEMATICS

Rena Upitis

Rena Upitis holds degrees in psychology, law, and education from Queen's University and an EdD from Harvard. She is a practising musician and has taught music in inner-city schools in the U.S. and Canada. Her wide interests lead her to seek connections among the worlds of nature, the arts, computing, and teaching. She is a prolific writer, performer, and workshop leader whose publication credits include four books: *This Too is Music*; *Can I Play You My Song?*; *Cold Feet and Chicken Curry: Reflections on Teaching*; and *I Made it in Math: Moving Beyond the Use of Manipulative Materials in the Mathematics Classroom*. Rena is Dean of Education at Queen's University in Kingston, Ontario.

Rena's chapter is important because it comes to grips with the two serious dilemmas in experiential education. One dilemma is to truly make students responsible for their learning, yet develop knowledge and insights within a particular discipline. The other is to evaluate learning, having regard for its deeply personal locus, especially when the learning is derived from individual pursuits. Rena uses a narrative account of her own teaching to highlight the joys, troubles, and adventure of personal projects with would-be teachers of elementary mathematics.

It's midwinter, but the sun shines boldly as if it were early spring. The window frames a cerulean blue sky, and it hurts my eyes to look at the melting snow. Icicles cascade over the eaves' troughs and shatter as they hit the ground. Smoke curls from my neighbour's chimney, and I remember I must go downstairs and add another log to the woodstove. But not just yet. I am painting the shadows of a glass jar and a red wooden horse, and I must work quickly or I'll lose the moment. Watercolour painting is tricky. A few seconds too soon or too late and the magic is gone. But no matter. Even if these shadows lose their translucence, I have more paper and more time. The afternoon is mine for painting—time I have set aside to play with this passion.

I began watercolour painting just over a year ago. It was something I always wanted to learn. I started with paper, paint, and a book for beginners. After a few months of joy and frustration, I found a teacher. I've been taking lessons—and painting—ever since.

I teach at the Faculty of Education at Queen's University. The courses I teach are varied—including elementary mathematics, music, arts-based education, and computers in education. Despite the diversity of these offerings, I have one assignment common to all the courses I teach: the personal project. Recently, I chose watercolours for my personal project for a math course I was teaching. Watercolour painting has been one of my most successful personal projects to date, for not only was I able to come to understand mathematics in new ways, but I loved what I produced—and I still paint.

The personal project, simply put, requires students to learn something they have never tried before and to document their progress in whatever manner best suits their needs. I also take part by completing this assignment, believing, as Herndon (1971) so aptly pointed out, that I should only ask of my students what I would willingly do myself. Herndon was a writer and educator who provided rich and powerful stories of teaching in the tradition of Kozol (1975) and Dennison (1969). He claimed many school structures stand in the way of learning, one of which is the presence of grading—another issue I deal with in the context of the personal project.

While the experience of the personal project has similar outcomes regardless of the course for which it is assigned, the discussion in this chapter focuses on how the personal project works in the area of mathematics teaching. My reason for picking this area over the others is that mathematics, at first blush, is perhaps one of the least likely candidates for experiential learning—at least in terms of the traditional ways that mathematics (or arithmetic) has been taught (Papert, 1993). I will describe the features of the personal project and the kind of learning that takes place as a result of these undertakings. Implications for teaching and learning mathematics in light of school expectations and practices will also be discussed.

Features of the Personal Project

The most central aspect of the personal project is that students are asked to learn about something new or do something *they have never done before.* They are given the opportunity to become fully engaged in a pursuit of their *own* choice, with no strings attached. By giving students this opportunity, I am not asking for a list of curriculum topics that could be taught in the formal setting. I am simply asking them to learn about something new, on their own initiative, and by whatever means they see fit. Many lessons are learned outside of school, and by asking future teachers to concentrate some of their learning efforts outside the school setting, they are reminded that as classroom teachers they affect some, but by no means all, of their students' learning.

In giving students this opportunity, I must be prepared to support projects that I would not be interested in pursuing myself. For that matter, I may find myself supporting projects in which I think there is little room for significant learning. (In this latter case, I often find I am wrong—just because I can't imagine the learning that will take place, doesn't mean the project isn't worthwhile for the student.) I must also be prepared to give students time to choose their projects—sometimes it takes up to two months for students who make four or five false starts to settle on their final project. In fact, I

often try one or two ideas myself before settling in—and I have been giving myself this assignment for some years.

The projects are personal in that the students make their own choices, but "personal" does not mean "alone." Sometimes students will work on personal projects together—when several people find they are all interested in knitting, for example, they may choose to work at the same time on their individual projects. Sometimes the actual product is a joint effort—for example, a group of students making a quilt. In any case, the personal projects almost always involve a larger learning community in that the students usually find they need the help of others to complete their projects. Even those students who prefer to work alone will want to share their work with peers at some point in the process.

Reflection on one's own learning is one of the expectations—students are asked to keep notes, a log, or a journal—some record of their work, the people they used as resources, the frustrations and joys they encountered (if students made false starts, a record of these trials is to be kept as part of the process of making a personal choice). This record is then used to write a summative reflective piece in the hope that students will be able to articulate something about their own learning. In the math course, I ask students to find the math in their personal projects (see excerpt below); this could be done with other disciplines as well.

The personal projects take several months to complete. At various times, I ask students to share their work, in groups of four or five, discussing the progress they are making on their respective projects. I also join one of the groups for this ongoing sharing.

I believe it is vital that I undertake a personal project along with the students, partly because I believe in the strength of modelling, but more so because it puts me in a better position to understand the nature of my students' undertakings. Besides, going back to Herndon's (1971) point—why should I ask of my students something that I won't do myself?

Finally, the personal project brings with it no threat of evaluation—there are no hidden hoops to jump through for the final grade (Falbel & Higginson, 1985). The personal projects do not get marked. Students are told at the outset that they will be expected to share their project, if possible, and to write journals and a reflective

piece. They are also told they will get an "A" for their efforts (or whatever a high mark might be in the particular context; when I did something similar with high school students, I gave them all 96%). But giving a high mark at the outset does not mean that I don't ask for hard work or, indeed, that the students don't ask it of themselves. In fact, students often report that they've worked harder for the personal project than for other courses, despite the pre-assigned grade. I like to think of it in terms of a phrase coined by Papert, where a situation of "demanding permissiveness" is created. Students are expected to work hard on their personal projects once they settle on an idea, but they are given extremely wide latitude in choosing their projects (Papert, 1993, p. 124).

In every way possible, then, the personal project puts learning in the hands of the students—with no strings attached.

Description of the Personal Project Assignment

The following excerpt describing the personal project assignment is taken from my course outline for a primary-junior mathematics curriculum course for pre-service teachers.

> Learn about something new or do something you have never done before. It should be something that matters to you, something that you think might be useful, something that you would enjoy (and not classify as one of life's "busywork" assignments). Oh yes—it would be nice if the "something" was related to mathematics. You could . . .
>
> - make a quilt
> - make stained glass
> - try Thai cooking
> - take ballroom dancing
> - learn sign language
> - try watercolours
> - compose some music
> - learn Spanish
> - build a robotics wonderland
> - take a life-drawing class
>
> As you engage in your personal project, keep a log or a journal or set of notes, if only haphazardly. From these notes, generate a brief

description of what you found—what the experience was like, what you observed, felt, wondered about, liked, disliked, marvelled at—and learned. I'd also like you to identify the mathematics involved. . . .

People choose a variety of personal projects—making a cribbage board, ballroom dancing, making stained glass, woodworking, making twig furniture, learning to bake bread, making wine, print making, photography development, and learning to fly an airplane (some personal projects gave "risk-taking in teaching and learning" a whole new meaning). I encourage students to choose a project for the love of it, rather than worrying about the mathematics involved. I assure them that we'll play "Where's the math?" (a distant cousin to "Where's Waldo?") as the term progresses, and not to worry if they are concerned that there will be little math in their projects. This is one of the functions of the small-group discussions; often one's peers can see some of the math more readily than the person directly involved with a project.

Initial Reactions

The feelings and learning we encounter through this experience are as varied as the projects themselves. Some students' initial responses to the personal project are nothing short of gleeful. They speak of how it is wonderful to be given this kind of chance, and list many ideas that leap to mind for possible projects. Later, many write about this initial response, reflecting that rarely have they been given an opportunity in school to truly pursue their own learning. For example:

> When we were first asked to do a personal project as an assignment, I was absolutely elated! Finally, someone is interested in what we want to learn. I came up with all sorts of ideas. . . . (Roy Choudhury, 1993, p. 1)

> When I first realized this assignment would be something I actually enjoyed doing, I was surprised. In my nineteen years of schooling no one has ever given me complete freedom of choice. There were

> many teachers who provided me with choice, but somewhere in the assignment there was always a catch. (Philpot, 1993, p. 1)

Students like these are enthusiastic about taking charge of their own learning. Perhaps they have already done this outside school, which leaves them poised to take advantage of the personal project assignment. Papert (1993) makes the convincing argument that if children practice taking charge of their own learning, then as adults they will have developed a sense of intellectual identity and will be able to "define and redefine their roles throughout a long lifetime" (p. 24). Papert describes how his own personal projects—starting a newspaper as a child, learning to juggle, learning to fly a plane—have affected him profoundly, and given him the opportunity to observe and theorize about his own learning. He further argues that school tends to inhibit the possibility of children taking charge of their learning, as they are more often than not in a "position of having to do as they are told, to occupy themselves with work dictated by someone else . . . [work] that has no intrinsic value" (p. 24).

One wonders if the school experience explains, in part, why other students respond to the personal project in less than enthusiastic ways. Some students are frightened by the open-ended nature of the assignment, and approach me in private after class saying, "Just tell me what to do." Others find the assignment interesting in principle but, because they fear mathematics, they cannot imagine how they could learn something new *and* deal with the mathematics involved. Usually about a third of the students are uncomfortable with the personal project, either because of the potential mathematics involved or because they have had few opportunities to make their own choices throughout their schooling, and are therefore unprepared to make a choice. As Illich (1983) so aptly argues, the pervasiveness of school as a public institution creates a dependence on school and its practices for learning; as Papert claims, a "superstitious belief in its methods" (p. 141).

Some students complicate the issue even further by wondering how they could apply their personal project to a classroom setting. To these students, I find myself frequently stressing the "personal" part of the "personal project," reiterating that the project is for them, not for their future students. This phenomenon of wanting to relate everything to a classroom situation is also described by

Papert (1993). In a workshop setting, he found himself frustrated with participants who thought of themselves as "teachers-in-training rather than as learners . . . [where] their awareness of being teachers was preventing them from giving themselves over fully to experiencing what they were doing as intellectually exciting . . . in its own right, for what it could bring them as private individuals" (p. 72).

In the last two math courses I have taught, from which the excerpts in this chapter are taken, the students uncomfortable with the assignment designated a spokesperson to talk to me about their discomfort and confusion. In both cases, the women speaking for the larger groups have themselves been delighted by the assignment, but have well understood the confusion on the part of their peers. I assured these students that there were truly "no strings attached," and with that assurance, they returned to the disgruntled group, explained the features of the assignment once again, and watched the confusion slowly turn to engagement and enjoyment. Some of the students who were initially uncomfortable with the personal project wrote:

> My first reaction to this project was utter panic. I felt somehow threatened by the open-endedness of the assignment, and could not decide what the project should be. This panic was fuelled by the conflict between my desire to fulfil the requirements of the course to the letter and my desire to find creative fulfilment in a tried-and-true, safe activity, like writing. . . . It would have been much, much easier for me if there had been guidelines other than "do something you have never done before." I needed to know what the teacher's objectives were before I could come to a final decision. (Burbidge, 1993, p. 1)

> When I first heard that we were to decide upon a personal project...I thought, "Oh no, how am I ever going to decide what to do?" I am a product of the school system where children are told everything that they are to do for every class, and when a decision like this is left up to me, my initial reaction is to panic. Fortunately, once I calmed down . . . I began to come up with a few ideas. (Bitterman, 1993, p. 1)

A third, very small group of students, aren't threatened by the prospect of making a choice, but feel that the assignment can't have any significant value for a course in mathematics. This tends to happen most often with students who have excelled at traditional mathematics curricula, often taking a number of math courses in high school and university. For these students, the personal project is not real math. A case in point appears below.

> I came into this course very excited. I have always liked math and couldn't wait to try teaching it myself. To me math was "textbook math." I have always liked math because there was a right or a wrong answer and not a "how much can I B.S. my way through this" answer. Math was something that always boosted up my self-esteem. I was always proud of my math abilities, especially since most of my friends practically broke out in tears anytime they saw a math book. . . . Then came the personal project. Being the math textbook person that I am, I thought, "What a dumb thing to have us do. How are you going to learn math by making something?" OK, so I put off the project as long as I could. First I was going to make a kite. . . . I decided on a gingerbread house . . . but I still thought, ". . . I can't believe I'm making a gingerbread house for a math project." My friends laughed at me and said, "So that's what you do in University nowadays." (Tomasevic, 1993, pp. 1-2)

I admit that as I was reading this piece, I was worried. I was unaware of the upheaval the personal project had caused this student. I was even more concerned about her choice of a personal project. As I stated earlier, sometimes "no strings attached" includes supporting projects that I think may not be the most enlightening in terms of mathematics. I felt that the gingerbread house would be that kind of project—that the student and her peers would build the house without difficulty, and they would all be left wondering why I had created such an assignment, convinced that "textbook math" was the only legitimate vehicle for teaching mathematics.

As it turns out, I needn't have worried. Even building a gingerbread house—which to me seemed a much simpler undertaking than, say, making a stained glass window, resulted in important learning for the student. Kathy continued:

> That just goes to show you [my friends] were just as cheated as I was out of what could have been a wonderful math education. It is no wonder so many of them hate math. How could you not hate something that involved doing pages and pages of the same type of work day after day? Some of us only liked it because of the self-esteem thing. . . . Ask me to do something that involves math skills that are not so obvious; I am no longer good at math . . . [e]verything was moving along nicely until we had to assemble the parts of the house . . . and realized the roof [would not] cover the house. . . . I sat there in disbelief and began to wail. . . .
>
> What I am trying to say is that my view of math and how it should be taught has completely changed. . . . I can't stop looking for math in everything I do. (Tomasevic, 1993, pp. 2-3)

A more detailed look at how students journey through the personal project follows.

Early Stages

One of the most common occurrences in the early stages of the personal project is that students (myself included) often change their minds about the projects they will undertake. Having decided to try something "simple," they often find that their simple ideas are not so simple and, for one reason or another, abandon them. Sometimes they abandon projects because they turn out to be too costly; sometimes they want to take a course—say in pottery—that is already full, and consequently need to choose something else. Sometimes students abandon projects out of frustration—and sometimes because they simply don't like what they're doing. Of all of these reasons, the last is perhaps the least acceptable in school terms. When I was visiting a tourist turn-of-the-century schoolhouse on Prince Edward Island, I read on the blackboard:

> *If a job is once begun, never leave it 'til it's done;*
> *Be the labour great or small, do it well or not at all.*

My sense is that this little ditty still reflects the sentiment of many teachers. While I believe it is often right to ask a student to

persevere and complete a project he or she begins, I believe it is even better to help him or her recognize when the best decision is to abandon the project. Often the personal project causes students to reflect in a similar manner, and they relate how they will try to recognize when it makes sense for one of their students to stop or give up, even though a job isn't completed. One student wrote:

> At this stage, I clued in that if a reasonably normal adult can change her mind so frequently . . . then as a teacher I should remember this when [a student] decides to scrap a struggling plan for a new one. (Theilmann, 1993, p. 2)

One of the other aspects in the early phases of the personal project is the prospect of gathering the materials required to do the work. Some approach this phase with excitement; purchasing the materials gives them a positive feeling about the entire undertaking. I certainly fall into this category—I love the feeling of going on a shopping expedition for a new adventure. For others, however, there is real trepidation involved, as even buying materials can expose one as a learner. This makes some people feel uncomfortable and vulnerable. The same student quoted above wrote:

> Straight ignorance gave me the willies as I entered [the art supplies store for my materials]. . . . [Since I was] obviously looking lost, a very kind lady approached me to see if I needed assistance. . . . I told her my sister likes to make jewellery and I wanted to purchase supplies for her for a Christmas gift—an outright lie! (Theilmann, 1993, p. 1)

Mid-Phases

Once the project has been chosen, materials have been secured, and some initial attempt has been made on the personal project, difficulties and frustrations invariably set in—even when people choose what they deem simple projects. The following comment was made by a student who decided to make a cribbage board out of driftwood from a beach near the university:

> The journey was much rougher than I expected. . . . [I] began with a simple idea . . . yeah, right. This idea soon became not so simple. . . . (Brown, 1993, p. 1)

Since adult students generally expect some difficulties to occur, they are surprised by the impatience they feel when their projects cause them anxiety. This leads some students to change their projects entirely, while others stick with their projects despite the difficulties encountered—"when one is deeply involved in something, 'easy' is not what one wants" (Papert, 1993, p. 48). The following journal excerpts, written by a woman learning to crochet an Afghan, illustrate well the cycle of enjoyment-frustration-enjoyment:

> *24/10/93*
>
> I am starting to get really excited about this. . . . I have beautiful blue wool. . . .
>
> *25/10/93*
>
> So far, so good; only worked for 2 hours.
>
> *6/11/93*
>
> I am very frustrated but I don't want to give up on this pattern. . . .
>
> *11/11/93*
>
> Looked at it again, pulled it out and started again. No luck. I am a glutton for punishment.
>
> *12/11/93*
>
> What a relief. Now I am getting somewhere. . . .
>
> *14/11/93*
>
> Piece of cake! I know how to crochet!
>
> *16/11/93*
>
> This is very relaxing. . . . (Rothmuller, 1993, pp. 1-4).

Yet another group of students experience anxiety when they begin to discover the kinds of tools they will need to produce their piece. One student wrote of his healthy respect for a router, having put a hole through a piece of pine he was sculpting. Another student, learning to upholster furniture, commented:

> My bubble burst abruptly when my husband informed me I would need to buy some upholstery tools. I wrote in my journal, "The idea that there might be tools involved means this is going to be technical. Technical scares me." (Burbidge, 1993, p. 1)

Personal projects invariably take many more hours than expected—even I am surprised by my inability to gauge the time I need for a new undertaking. In one of my papers, I wrote:

> I've done a fair number of personal projects over the years. So, by now, I should be getting good at them. . . . It still takes me a long time to do each project, always longer than I think. (Upitis, 1993, p. 1)

There is nothing wrong with taking a long time to learn something. In fact, taking the time to learn is something we rarely do, and school tends not to encourage this because its very structures cause the "chopping" of time (Papert, 1993, p. 89). By making the personal project the major assignment of the course, I can give students time they may not give themselves—the time they would normally take completing four or five other assignments for the math course can be spent for the personal project—it is time students have already budgeted for school work; the personal project changes the nature of that school work.

Learning Issues

One of the most important revelations students have as they engage in the personal project is that there is a great deal of mathematics involved in their pursuits. Students are always surprised by this and, further, many realize that it is important to articulate the mathematics involved. That is, just using the math to accomplish the project goals is not enough. After all, as several

students have pointed out, many people use math successfully for years—especially women doing "women's work" like sewing and cooking—and yet see themselves as math illiterate or describe themselves as math-phobic. Part of the reason for this is that they have never thought of these pursuits in mathematical terms. Some related quotations follow:

> You can see all the math that was needed to design and make this. . . . I couldn't believe it until I started to write this. (Patrick, 1993, p. 2)

> I was also a little worried that I wouldn't be able to find a lot of math in crocheting—I was wrong. Right from the start, I jumped into math. (Hick, 1993, p. 1)

> I've thought of something else. At the most basic level, we are also dealing with left-right/up-down/and side-to-side concepts. These are so automatic we don't even think about them. But we would be continually thinking about these concepts if we had a learning disability and had to struggle with them. (Senra, 1993, p. 3)

Another equally important learning issue was the role of learning through social interaction. Some people found it preferable or even necessary to involve others in their learning. Many wrote about how they involved their fiancés, friends, and family members in their work, often noting that this was the only school assignment they found useful and helpful to share. One woman said that she had her 3-year-old daughter help her decorate the musical instruments she had constructed, and commented further that she would not have involved her had the personal project been like other assignments and faced the grading process upon completion. Interestingly, this student noted that her end product was more engaging and artistically successful with her daughter's input—even though she feared that her daughter might ruin the work, and wouldn't have risked having her help had the project been marked.

Some other comments regarding the importance of involving others appear below:

> I knew that the initial teaching [for knitting] had to be done by a very patient friend. (Duncan, 1993, p. 1)

> The social aspect of the [watercolour] course was a significant element in my enjoyment of the course. The atmosphere was so casual and friendly . . . not only did I discover a love of painting and of drawing during the course, but I met some really neat people as well. (Grant, 1993, p. 2)

While some students enjoyed and even depended on the involvement of peers and family, others took the opposite approach, either because they feared exposing themselves as new learners, or because they revelled in the time they could spend alone. One woman falling into the latter category said she used her crocheting time for personal thought, wandering from one topic to another in her mind. Every Friday night she had a date with her Afghan and a pot of chamomile tea. Someone falling into the former category, that is, not wanting to show her vulnerability as a new learner, wrote:

> Considering my complete lack of experience with painting anything other than the walls with a roller, learning from a book seemed the best method for avoiding embarrassment. (Craig, 1993, p. 1)

Certainly the time spent on the personal projects became valued time for most students. The comment below made me realize how few assignments give students the opportunity to make something with their hands; small wonder that so many personal projects involve handwork of one form or another. This comment comes from the student quoted earlier, who was frustrated with the tools required to upholster furniture:

> It was therapeutic to work with my hands after frustrating days of discussing theories of education. . . . (Burbidge, 1993, p. 1)

I certainly concur with this observation. As I described at the outset, watercolour painting for me has become an outlet—a way of balancing the teaching, marking, and yes, chapter writing, with other ways of engaging my hands, heart, and mind.

Implications

In terms of general implications, perhaps the most important one dealing directly with mathematics is that almost all students report that, as a result of the personal project, they are now seeing math everywhere:

> Meanwhile, I learned about tessellations in math class. Tessellations are now taking over my life; I find them everywhere (I'm beginning to consider therapy). My project just had to tessellate! (McWhirter, 1993, p. 1)

> When we introduced ourselves on the first night of the course, we all announced why we were taking the [watercolour painting] course. I said that part of my reason was to fulfil a component of my math course, and that I was here to find the math in watercolours. Everyone, of course, looked at me as if I were crazy. I was a bit doubtful myself. However, one of the first exercises we did that night was to draw, conceptualizing everything as one of four three-dimensional shapes—a cube, cylinder, cone, or sphere. . . . I realized in doing this personal project that math lessons do not have to be ditto sheets, but that math really is all around us. (Grant, 1993, pp. 1-2)

Along with "seeing math everywhere" comes an increased level of confidence with one's own math abilities. This is crucial for future teachers of mathematics, many of whom come to the first math class with visible anxiety on their faces and in their body movements. I am convinced, as are the students who write below, that exploring one's math abilities in a real context does far more for elevating one's self-confidence than passing achievement tests.

> It was great to have the opportunity to use math in a real life context. By doing something I was interested in, I didn't mind doing the math. In fact, it was rather enjoyable searching for the math—like a game. . . . This personal project has definitely increased my confidence in my mathematical abilities. (Smith, 1993, p. 3)

> Strange—this personal project taught me to find the math in "normal" activities. . . . However, it is still difficult for me to "find the math" in an activity because, basically, doing so threatens my enjoyment of the activity. Now, I didn't say *ruins* my enjoyment, because

> I am now comfortable enough with math to find it and use it . . . but my old (and still very present) fear of math makes me automatically shy away from it. Now that I know I can do it, I have to learn how to feel that I can do it. That will be my goal during my next personal project. (Duncan, 1993, pp. 1-2)

> I'm sure you know these personal projects have not only affected our class, but everyone we come in contact with. In a building full of future teachers, many now understand that math can be found everywhere in everything we do. And even if there are some who didn't understand what we have told them about finding the math in our personal projects, they'll be perplexed now. They weren't perplexed before. (Assinck, 1993, p. 1)

As mentioned earlier, for some students, this notion of math ability or talent was closely tied to gender. Many of the women students noted that not only could they "see math everywhere," but felt more confident in their abilities because they realized they had been doing math all along in their daily lives. Two particularly strong excerpts in this regard appear below:

> When I was thinking about what I would do for my personal project and [Rena] mentioned in class the option of knitting, I immediately thought "Where is the math in that?" As I started to crochet my baby's blanket I began to see what [Rena] [was] talking about...[this project] made me realize how much math we use in everyday life. It made me feel, and now here comes my quasi-feminist statement, how undervalued many things have been in the past. Sewing, crocheting, and knitting were traditionally thought of as "women's work." . . . [The personal project] showed me how many skills, especially mathematical ones, women possessed and were traditionally considered incapable of possessing. My maternal Grandmother taught me how to knit and sew when I was a small child. I do not think my Grandmother realized she possessed a number of math skills in order to make her crafts; I think these skills were viewed by her and most people as "real-world realities," as something you just knew. (Haines, 1993, pp. 1-2)

These observations are like those made by Lave (1988), a cognitive anthropologist who has demonstrated not only that women know and use mathematics in household tasks, but that the mathe-

the students, will not necessarily work for others. Many of the math students came to grips with this—and other learning issues—through the personal project, and by sharing their views in the small-group discussions.

Numerous other features of the learning environment were raised as well, including the role of structured expectations and directions, the need to feel the work had real educational value or practical purpose, the need for approval (even applause) from teacher and peers, and the importance of taking a hands-on approach to solving the practical problems of the personal project. One student also talked about how she was highly motivated by the end product, even though she realized the importance of process in this assignment. She talked of her fear of failure and preoccupation with the final product, stating:

> I feel these views may have been influenced or even created by my socialization to the process and expectations of the educational system. Since I consider these negative points, I would hope, as a teacher, to influence my students in other directions. (Burbidge, 1993, p. 3)

Thinking about one's own learning invariably led to new ways of thinking about teaching. Pre-service teachers, along with their more experienced colleagues, are well aware that people learn in different ways and at different rates. But it is one thing to know about learning styles intellectually, and another thing altogether to *feel* what those differences mean. Since the personal project involves learning something new, many students find that they are given a context for experiencing what they know—in short, by putting themselves in the shoes of a learner, they better understand what it means to be taught. For example:

> I felt like I had lost all control in my hands and fingers. At first, it was extremely awkward . . . and frustrating, because I couldn't remember what I was supposed to be doing. I also had to practically count out loud to keep track of what stitch I was on. (Kimmett, 1993, p. 1)

> I always knew that people learned in different ways, but I never realized how subtle the differences could be. . . . An interesting lesson I learned was that everyone has bad days. Some days I would start crocheting and I just could not follow the pattern. It may have been that my mind was somewhere else . . . regardless, I couldn't complete a row. This . . . is something I will definitely need to take into consideration when I am teaching. . . . (Philpot, 1993, p. 3)

Many continued with specific plans for their own teaching—like providing a variety of ways of introducing new concepts and tasks—oral, written, diagrams, models—but not enforcing the use of one method over another. Others noted that they would try not to interfere with students' work unless they were asked for assistance. There is nothing earth-shattering or novel about these approaches. Many educators advocate the use of multiple representations for teaching, based in part on the work of psychologists like Gardner (1983) who have demonstrated different kinds of intelligences or

strengths in making sense of the world. Likewise, educators have stressed the importance of offering help to students only when it is solicited, rather than providing unasked-for help at every turn (Falbel, 1989). What is significant here is that these pre-service teachers are making these same conclusions on their own, on the basis of an experience which is strong enough to shape their view of mathematics and teaching and learning.

The significance of the personal project to students is further demonstrated by the fact that many describe future personal projects they plan to undertake, realizing the importance of giving more than lip service to the notion of lifelong learning:

> [T]he most important thing I learned by doing this project was the fact that I need to *make* time for those important things that I want to learn. I have even started to decide what my project will be next term! (Wells, 1993, p. 2)

The personal projects are worth doing, in and of themselves. That there are learning outcomes related to mathematics—or any other number of disciplines, for that matter—is secondary. One does not engage in personal projects because there is mathematics to be learned through them. One engages in the projects because they are a worthwhile way to spend some time. Although I ask students to articulate the mathematics so that they become more aware of the math involved, I do not ask them to choose the project with math in mind—the math emerges. One student echoed this sentiment in terms of how she would pick an activity the next time for herself, and for her students:

> I think that is the trick: to find learning outcomes that relate to what I have done, rather than trying to find an activity that fits the outcomes. (Duncan, 1993, p. 2)

Too often our approach is the opposite—instead of beginning with a worthwhile idea, we begin with things we want to teach, and try (often in vain) to find activities to fit. Or as Papert (1993) writes, "Geometry is not there for being learned. It is there for being used" (p. 17). And geometry is there for being used in personal ways—just because a quilt turns out to be a good project for one person

doesn't mean an entire class should now engage in the same activity. Again, quoting from Papert, "significant engagement [is] too personal to be expected to operate as a mass effect . . . reasons [for engagement] are as personal and in a sense as unreproducible as those that determine any kind of falling in love" (p. 27).

Finally, I would like to raise the issue of how many of these worthwhile activities, chosen out of personal interest rather than out of their potential mathematical riches, turned out to have something to do with visual art or music or, generally, had an important aesthetic component. When we are given the chance to learn something new, nearly everyone gravitates toward making something, and trying to make something beautiful. The beauty of mathematics and its strong relation to the arts is often underplayed in traditional curricula. Yet, this is perhaps the most convincing way to make mathematics real for our students. One teacher wrote:

> I see art and math together, and these are the two [subjects] that are the most often [at] opposite ends of the spectrum. In schools we [often] disengage these two subjects, when in reality, they complement and support each other at the most basic level . . . neither can escape the other . . . instead of spending all our time dividing and isolating things, a more sensible . . . [approach] would involve an integration of thoughts and processes. (Senra, 1993, p. 6)

Another student shared the following quotation by a mathematician named Morris Kline, found somewhere in a book of phrases about learning mathematics, the source of which, unfortunately, has been lost.

> A mathematician, like a painter or a poet, is a maker of patterns. The mathematician's patterns, like the painter's or the poet's, must be beautiful, the ideas, like the colours or the words, must fit together in a harmonious way. Beauty is the first test. There is no permanent place in the world for ugly mathematics.

The personal project provides a window for teachers to see the beauty of mathematics.

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